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(54) Molded electrical device and composition therefore.

(57) This invention is directed to a molded electrical device comprising an electrically conductive pathway and an insulating material, and capable of interconnecting with external circuitry said insulating material comprising a blend of a particular amorphous polymer and a particular crystalline thermoplastic polymer. Also, this invention is directed to a composition suitable for use as an insulating material in an electrical device comprising from about 35 to about 65 weight percent of an amorphous polymer selected from a polyarylethersulfone resin, a polyarylether resin, a polyetherimide or a polyarylate, and from about 65 to about 35 weight percent of a crystalline polymer selected from a poly(arylene sulfide), a polyester or a polyamide.

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**MOLDED ELECTRICAL DEVICE AND  
COMPOSITION THEREFORE**

**BACKGROUND OF THE INVENTION**

This invention is directed to a molded electrical device comprising an electrically conductive pathway and an insulating material, the device being capable of interconnection with external circuitry, said insulating material comprising a blend of a particular amorphous thermoplastic polymer and a particular crystalline thermoplastic polymer. Also, this invention is directed to a composition suitable for use as an insulating material in an electrical device comprising from about 35 to about 65 weight percent of an amorphous polymer selected from a polyarylethersulfone resin, a polyarylether resin, a polyetherimide, or a polyarylate and from about 65 to about 35 weight percent of a crystalline polymer selected from a poly(arylene sulfide), a polyester, or a polyamide.

It is well known that a wide variety of thermoplastic polymers have been used as substrates for electrical components, such as circuit board substrates. These substrates have been molded from, for example, polyphenyleneoxide, polyphenylenesulfide, polyimide and polyethersulfone. Additionally, the following U.S. Patent Applications disclose substrates made from thermoplastic polymers:

U.S. Patent Application Serial No. 516,863, filed in the name of J.E. Harris et al, on July 25, 1983, titled "A Composition Useful For Making

**Circuit Board Substrates and Electrical Connectors"**  
(commonly assigned) describes a composition useful  
for making circuit board substrates and electrical  
connectors comprising a blend of certain proportions  
of a poly(ether sulfone) and a polysulfone.

U.S. Patent Application Serial No. 566,298,  
filed in the name of H. Chao et al, on December 28,  
1983, titled "A Polymer Useful For Molding Into A  
Circuit Board Substrate" (commonly assigned)  
describes a select polyarylethersulfone which is  
useful for molding into circuit board substrates.

U.S. Patent Application Serial No. 448,376, \*  
filed in the name of J.E. Harris, on December 9,  
1982, titled "A Composition Useful For Making  
Circuit Board Substrates And/or Electrical  
Connectors" (commonly assigned) describes a  
composition comprising a blend of a poly(aryl  
ether), a poly(etherimide) polymer, a fiber and a  
filler which is useful for making circuit board  
substrates and/or electrical connectors.

The polymers described above are used as  
circuit board substrates and in other electrical  
devices such as chip carriers. These materials are  
solderable by hand or wave soldering techniques.  
However, unlike hand and wave soldering, vapor phase  
soldering (VPS) constitutes a considerably more  
rigorous form of thermal exposure (as, for example,  
temperatures of about 420°F, and times of exposure  
of the substrate of from 30 seconds to in excess of  
2 minutes). Unlike wave soldering which involves  
momentary exposure of the device to temperatures of  
500°F, VPS requires that the electrical device be

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\* corresponding to European patent application 83 112 378.1

totally immersed in the soldering media. Thus, amorphous resin containing formulations that performed satisfactorily in hand and wave soldering exhibit deficiencies upon VPS exposure, i.e., they exhibit bubbles, blisters, distortion, and foaming. This is attributed to relatively high moisture absorption and low apparent modulus at the VPS processing temperature of the substrate made from amorphous resins.

Crystalline resin systems, on the other hand, have been found to exhibit low moisture absorption and a relatively high modulus at VPS processing temperatures. For example, mineral and/or glass-filled/reinforced poly(ethylene terephthalate) has demonstrated exceptional resistance to bubbling, blistering, and foaming in VPS exposure. However, while possibly suited for making small articles such as chip carriers, filled/reinforced poly(ethylene terephthalate) systems are unacceptable for printed wiring board fabrication due to anisotropic behavior which results in severe bow and warp of the fabricated wiring board. Thus, there is a desire to develop a resin formulation which can be used to fabricate a large variety of molded electrical devices requiring VPS exposure and which maintain their dimensional integrity after VPS exposure.

#### THE INVENTION

In the present invention it has been found that the combination of a particular amorphous thermoplastic polymer and a particular crystalline thermoplastic polymer provides a material which is

useful as an electrical/support element in electrical devices, is vapor phase solderable, and maintains its dimensional integrity.

The present invention is also directed to a molded electrical device comprising an electrically conductive pathway and an insulating material, the device being capable of interconnection with external circuitry, said insulating material comprising a blend of a particular amorphous thermoplastic polymer and a particular crystalline thermoplastic polymer.

Further, this invention is directed to a composition suitable for use as an insulating material in an electrical device comprising from about 35 to about 65 weight percent, preferably from about 40 to about 60 weight percent, and most preferably about 50 weight percent, of an amorphous thermoplastic polymer selected from a polyarylethersulfone, a polyarylether resin, a polyetherimide, or a polyarylate, and from about 65 to about 35 weight percent, preferably from about 40 to about 60 weight percent, and most preferably about 50 weight percent of a crystalline polymer selected from a poly(arylene sulfide), a polyester, or a polyamide.

Preferred compositions include blends of polyarylethersulfone with poly(arylene sulfide) or polyesters or polyamides or mixtures of one or more of these; polyarylether with poly(arylene sulfide) or polyesters or polyamides. Most preferred compositions include mixtures of polyarylethersulfone and polyesters, particularly

poly(ethylene terephthalate); mixtures of polyarylethers and polyesters; mixtures of polyarylethersulfone and poly(arylene sulfide) or mixtures of polyarylethers and poly(arylene sulfide).

#### The Electrical Device

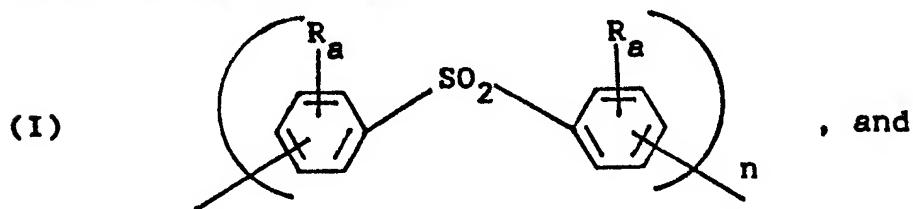
The electrical device of this invention includes chip carriers which are holders for microcircuits with contacts and wire bonding pads used to protect the microcircuit and interconnect it with a printed circuit board; printed circuit boards as an extruded injection moldable, or laminated support for additive or subtractively produced circuit elements and components; electrical connectors which are assemblies of conducting elements arranged in the insulating material of this invention and used for circuit element interconnection.

The chip carrier, printed circuit board and electrical connectors are made by well known methods in the art such as by injection, compression, or transfer molding or by lamination. Representative methods are described in, for example, U.S. Patents 4,147,889 and 3,975,757.

#### The Amorphous Polymers

##### A. Polyarylethersulfones

The polyarylethersulfones of this invention are amorphous thermoplastic polymers containing units of the formula:

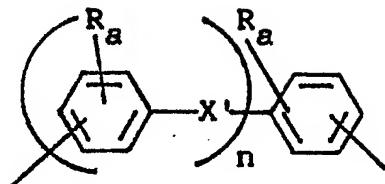


(II)

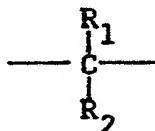


and/or

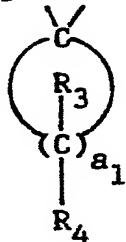
(III)



wherein  $R$  is independently hydrogen,  $C_1$  to  $C_6$  alkyl or  $C_4$  to  $C_8$  cycloalkyl,  $X'$  is independently



wherein  $R_1$  and  $R_2$  are independently hydrogen or  $C_1$  to  $C_9$  alkyl, or

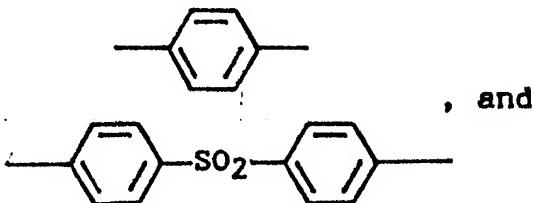


wherein  $R_3$  and  $R_4$  are independently hydrogen or  $C_1$  to  $C_8$  alkyl, and  $a_1$  is an integer of 3 to

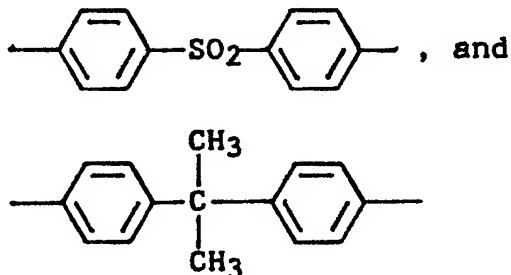
8;  $-S-$ ,  $-O-$ , or ,  $a$  is an integer of 0 to 4

and  $n$  is independently an integer of 1 to 3 and wherein the ratio of unit (I) to the sum of units (II) and/or (III) is greater than 1. The units are attached to each other by an  $-O-$  bond.

A preferred polymer of this invention contains units of the formula:



Another preferred polyarylethersulfone of this invention contains units of the formula:



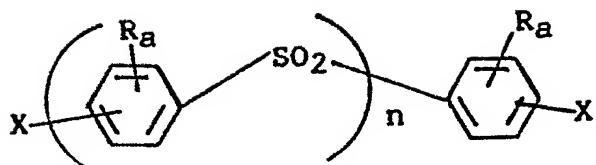
These units are attached to each other by an -O- bond.

The polyarylethersulfone may be random or may have an ordered structure.

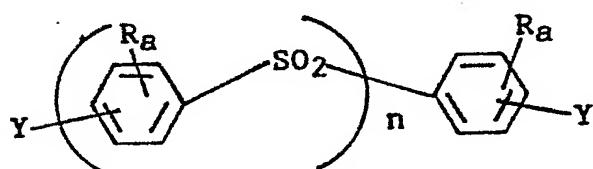
The polyarylethersulfones of this invention have a reduced viscosity of from about 0.4 to greater than about 2.5, as measured in N-methylpyrrolidone, or other suitable solvent, at 25°C.

The polyarylethersulfones of this invention are prepared by reacting the monomers represented by the following formulae:

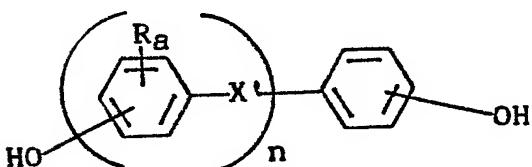
(IV)



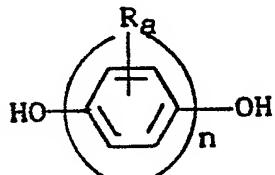
(V)



(VI)



(VII) and/or



wherein R, a, X' and n are as previously defined, and X and Y are independently selected from Cl, Br, F, NO<sub>2</sub> or OH and at least 50 percent of the Y's are OH.

The ratio of the concentration of OH groups to Cl, Br, F and/or NO<sub>2</sub> groups used to form the polyarylethersulfone is from about 0.90 to about 1.10, preferably from about 0.98 to about 1.02.

The monomers, represented by formulas (IV), (V), (VI) and (VII), include the following:

2,2-bis(4-hydroxyphenyl)propane,  
bis(4-hydroxyphenyl)methane,  
4,4'-dihydroxydiphenyl sulfide,  
4,4'-dihydroxydiphenyl ether,  
4,4'-dihydroxydiphenyl sulfone,  
2,4'-dihydroxydiphenyl sulfone,  
4,4'-dichlorodiphenyl sulfone,  
4,4'-dinitrodiphenyl sulfone,  
4-chloro-4'-hydroxydiphenyl sulfone,  
4,4'-biphenol, hydroquinone, and the like.

The preferred monomers include hydroquinone, 4,4-biphenol, 2,2-bis(4-hydroxyphenyl)propane, 4,4'-dichlorodiphenyl sulfone, and 4,4'-dihydroxydiphenyl sulfone or 4 chloro-4'-hydroxydiphenyl sulfone.

The polymers are prepared by contacting substantially equimolar amounts of the hydroxy containing compounds (depicted in formulas (IV) to (VII) supra) and halo and/or nitro containing compounds (depicted in formula (IV) and (V) supra) with from about 0.5 to about 1.0 mole of an alkali metal carbonate per mole of hydroxyl group in a solvent mixture comprising a solvent which forms an azeotrope with water in order to maintain the reaction medium at substantially anhydrous conditions during the polymerization.

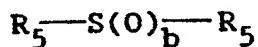
The temperature of the reaction mixture is kept at from about 120 to about 180°C, for about 1 to about 5 hours and then raised and kept at from about 200 to about 250°C, preferably from about 210 to about 230°C, for about 1 to 10 hours.

The reaction is carried out in an inert atmosphere, e.g., nitrogen, at atmospheric pressure, although higher or lower pressures may also be used.

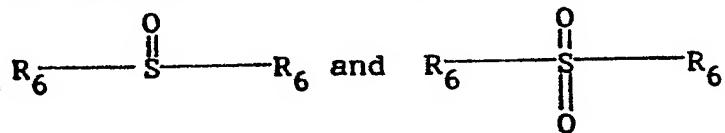
The polyarylethersulfone is then recovered by conventional techniques such as coagulation, solvent evaporation, and the like.

The solvent mixture comprises a solvent which forms an azeotrope with water and a polar aprotic solvent. The solvent which forms an azeotrope with water includes an aromatic hydrocarbon such as benzene, toluene, xylene, ethylbenzene, chlorobenzene, and the like.

The polar aprotic solvents employed in this invention are those generally known in the art for the manufacture of polyarylether sulfones and include sulfur containing solvents such as those of the formula:

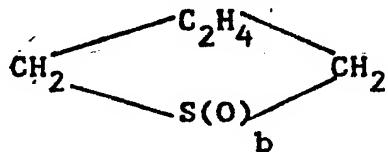


in which each  $R_5$  represents a monovalent lower hydrocarbon group free of aliphatic unsaturation, which preferably contains less than about 8 carbon atoms or when connected together represents a divalent alkylene group with  $b$  being an integer from 1 to 2 inclusive. Thus, in all of these solvents all oxygens and two carbon atoms are bonded to the sulfur atom. Contemplated for use in this invention are such solvents as those having the formula:



where the  $R_6$  groups are independently lower alkyl, such as methyl, ethyl, propyl, butyl, and like

groups, and aryl groups such as phenyl and alkylphenyl groups such as the tolyl group, as well as those where the R<sub>6</sub> groups are interconnected as in a divalent alkylene bridge such as:



in tetrahydrothiophene oxides and dioxides. Specifically, these solvents include dimethylsulfoxide, dimethylsulfone, diphenylsulfone, diethylsulfoxide, diethylsulfone, diisopropylsulfone, tetrahydrothiophene 1,1-dioxide (commonly called tetramethylene sulfone or sulfolane) and tetrahydrothiophene-1 monoxide.

Additionally, nitrogen containing solvents may be used. These include dimethyl acetamide, dimethyl formamide and N-methylpyrrolidone.

The azeotrope forming solvent and polar aprotic solvent are used in a weight ratio of from about 10:1 to about 1:1, preferably from about 7:1 to about 5:1.

In the reaction, the hydroxy containing compound is slowly converted, in situ, to the alkali salt thereof by reacting with the alkali metal carbonate. The alkali metal carbonate is preferably potassium carbonate. Mixtures of carbonates such as potassium and sodium carbonate may also be used.

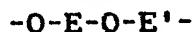
Water is continuously removed from the reaction mass as an azeotrope with the azeotrope forming solvent so that substantially anhydrous conditions are maintained during the polymerization.

It is essential that the reaction medium be maintained substantially anhydrous during the polycondensation. While amounts of water up to about one percent can be tolerated, and are somewhat beneficial when employed with fluorinated dihalobenzoid compounds, amounts of water substantially greater than this are desirably avoided as the reaction of water with the halo and/or nitro compound leads to formation of phenolic species and only low molecular weight products are secured. Consequently, in order to secure the high polymers, the system should be substantially anhydrous, and preferably contain less than 0.5 percent by weight water during the reaction.

Preferably, after the desired molecular weight has been attained, the polymer is treated with an activated aromatic halide or an aliphatic halide such as methyl chloride or benzyl chloride, and the like. Such treatment of the polymer converts the terminal hydroxyl groups into ether groups which stabilize the polymer. The polymer so treated has good melt and oxidative stability.

#### B. Polyarylether resin

The poly(aryl ether) resin suitable for blending with the polyarylethersulfone, is different from the polyarylethersulfone and is a linear, thermoplastic polyarylene polyether containing recurring units of the following formula:



wherein E is the residuum of a dihydric phenol, and E' is the residuum of a benzenoid compound having an inert electron withdrawing group in at least one of

the positions ortho and para to the valence bonds; both of said residua are valently bonded to the ether oxygens through aromatic carbon atoms. Such aromatic polyethers are included within the class of polyarylene polyester resins described in, for example, U.S. Patents 3,264,536 and 4,175,175. It is preferred that the dihydric phenol be a weakly acidic dinuclear phenol such as, for example, the dihydroxyl diphenyl alkanes or the nuclear halogenated derivatives thereof, such as, for example, the 2,2-bis(4-hydroxyphenyl)propane, 1,1-bis(4-hydroxyphenyl)2-phenyl ethane, bis(4-hydroxyphenyl)methane, or their chlorinated derivatives containing one or two chlorines on each aromatic ring. Other materials also termed appropriately bisphenols are also highly valuable and preferred. These materials are the bisphenols of a symmetrical or unsymmetrical joining group, as,

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for example, ether oxygen (-O-), carbonyl (-C-),

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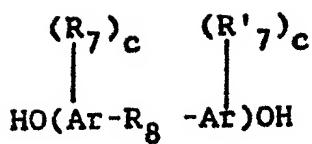
sulfone (-S-), or hydrocarbon residue in which the

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two phenolic nuclei are joined to the same or different carbon atoms of the residue.

Such dinuclear phenols can be characterized as having the structure:



wherein Ar is an aromatic group and preferably is a phenylene group, R<sub>7</sub> and R'<sub>7</sub> can be the same or different inert substituent groups such as alkyl groups having from 1 to 4 carbons atoms, aryl, halogen atoms, i.e., fluorine, chlorine, bromine or iodine, or alkoxy radicals having from 1 to 4 carbon atoms, the c's are independently integers having a value of from 0 to 4, inclusive, and R<sub>8</sub> is representative of a bond between aromatic carbon atoms as in dihydroxyl-diphenyl, or is a divalent radical,

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including for example, radicals such as -C-, -O-, -S-, -SO-, -S-S-, -SO<sub>2</sub>, and divalent hydrocarbon radicals such as alkylene, alkylidene, cycloalkylene, cycloalkylidene, or the halogen, alkyl, aryl or like substituted alkylene, alkylidene and cycloaliphatic radicals as well as aromatic radicals and rings fused to both Ar groups.

Examples of specific dihydric polynuclear phenols including among others: the bis-(hydroxyphenyl) alkanes such as 2,2-bis-(4-hydroxyphenyl)propane, 2,4'-dihydroxydiphenylmethane, bis-(2-hydroxyphenyl)methane, bis-(4-hydroxyphenyl)methane,

bis(4-hydroxy-2,6-dimethyl-3-methoxyphenyl)methane,  
1,1-bis-(4-hydroxy-phenyl)ethane,  
1,2-bis-(4-hydroxyphenyl)ethane,  
1,1-bis-(4-hydroxy-2-chlorophenyl)ethane,  
1,1-bis-(3-methyl-4-hydroxyphenyl)propane,  
1,3-bis-(3-methyl-4-hydroxyphenyl)propane,  
2,2-bis-(3-phenyl-4-hydroxyphenyl)propane,  
2,2-bis-(3-isopropyl-4-hydroxyphenyl)propane,  
2,2-bis-(2-isopropyl-4-hydroxyphenyl)propane,  
2,2-bis-(4-hydroxy-naphthyl)propane,  
2,2-bis-(4-hydroxyphenyl)pentane,  
3,3-bis-(4-hydroxyphenyl)pentane,  
2,2-bis-(4-hydroxyphenyl)heptane,  
bis-(4-hydroxyphenyl)phenylmethane,  
2,2-bis-(4-hydroxyphenyl)-1-phenyl-propane,  
2,2-bis-(4-hydroxyphenyl)1,1,1,3,3,3,-hexafluoro-  
propane, and the like;

di(hydroxyphenyl)sulfones such as  
bis-(4-hydroxyphenyl)sulfone, 2,4'-dihydroxydiphenyl  
sulfone, 5-chloro-2,4'-dihydroxydiphenyl sulfone,  
5'-chloro-4,4'-dihydroxydiphenyl sulfone, and the  
like;

di(hydroxyphenyl)ethers such as  
bis-(4-hydroxyphenyl)ether, the 4,3',-  
4,2'-2,2'-2,3-, dihydroxyphenyl ethers,  
4,4'-dihydroxyl-2,6-dimethyldiphenyl  
ether, bis-(4-hydroxy-3-isobutylphenyl)ether,  
bis-(4-hydroxy-3-isopropylphenyl)ether,  
bis-(4-hydroxy-3-chlorophenyl)ether,  
bis-(4-hydroxy-3-fluorophenyl)ether,  
bis-(4-hydroxy-3-bromophenyl)ether,  
bis-(4-hydroxynaphthyl)ether,

bis-(4-hydroxy-3-chloronaphthyl)ether, and  
4,4'-dihydroxyl-3,6-dimethoxydiphenyl ether.

As herein used the E' term defined as being the "residuum of the dihydric phenol" of course refers to the residue of the dihydric phenol after the removal of the two aromatic hydroxyl groups. Thus as is readily seen these polyarylene polyethers contain recurring groups of the residuum of the dihydric phenol and the residuum of the benzenoid compound bonded through aromatic ether oxygen atom.

Any dihalobenzenoid or dinitrobenzenoid compound or mixtures thereof can be employed in this invention which compound or compounds has the two halogens or nitro-groups bonded to benzene rings having an electron withdrawing group in at least one of the positions ortho and para to the halogen or nitro group. The dihalobenzenoid or dinitrobenzenoid compound can be either mononuclear where the halogens or nitro groups are attached to the same benzenoid rings or polynuclear where they are attached to different benzenoid rings, as long as there is an activating electron withdrawing group in the ortho or para position of that benzenoid nuclear. Fluorine and chlorine substituted benzenoid reactants are preferred; the fluorine compounds for fast reactivity and the chlorine compounds for their inexpensiveness. Fluorine substituted benzenoid compounds are most preferred, particularly when there is a trace of water present in the polymerization reaction system. However, this water content should be maintained below about 1% and preferably below 0.5% for best results.

An electron withdrawing group can be employed as the activator group in these compounds. It should be, of course, inert under the reaction conditions, but otherwise its structure is not critical. Preferred are the strong activating

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groups such as the sulfone group (-S-) bonding two  
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halogen or nitro substituted benzenoid nuclei as in the 4,4'-dichlorodiphenyl sulfone and 4,4'-difluorodiphenyl sulfone, although such other strong withdrawing groups hereinafter mentioned can also be used with equal ease.

The more powerful of the electron withdrawing groups give the fastest reactions and hence are preferred. It is further preferred that the ring contain no electron supplying groups on the same benzenoid nucleus as the halogen or nitro group; however, the presence of other groups on the nucleus or in the residuum of the compound can be tolerated.

The activating group can be basically either of two types:

(a) monovalent groups that activate one or more halogens or nitro-groups on the same ring such as another nitro or halo group, phenylsulfone, or alkylsulfone, cyano, trifluoromethyl, nitroso, and hetero nitrogen, as in pyridine.

(b) divalent groups which can activate displacement of halogens on two different rings,

such as the sulfone group  $-S-$ ; the carbonyl group  
 $\begin{array}{c} O \\ || \\ " \end{array}$

$\begin{array}{c} O \\ || \\ " \end{array}$        $\begin{array}{c} H \\ | \\ " \end{array}$   
-C-; the vinylene group -C=C-; the sulfoxide group  
 $\begin{array}{c} H \\ | \\ " \end{array}$

$\begin{array}{c} O \\ || \\ " \end{array}$   
-S-; the azo group -N=N-; the saturated fluorocarbon  
 $\begin{array}{c} CF_3 \\ | \\ " \end{array}$   
groups -C-, -CF<sub>2</sub>, -CF<sub>2</sub>CF<sub>2</sub>-; organic phosphine  
 $\begin{array}{c} CF_3 \\ | \\ " \end{array}$

$\begin{array}{c} O \\ || \\ " \end{array}$   
oxides -P-:  
 $\begin{array}{c} " \\ | \\ R_9 \end{array}$

where R<sub>9</sub> is a hydrocarbon group, and the ethylidene group A-C-A where A can be

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-C-

hydrogen or halogen.

If desired, the polymers may be made with mixtures of two or more dihalobzenoid or dinitrobenzenoid compounds. Thus, the E' residuum of the benzenoid compounds in the polymer structure may be the same or different.

It is seen also that as used herein, the E' term defined as being the "residuum of the benzenoid

"compound" refers to the aromatic or benzenoid residue of the compound after the removal of the halogen atom or nitro group on the benzenoid nucleus.

The polyarylene polyethers of this invention are prepared by methods well known in the art as for instance the substantially equimolar one-step reaction of a double alkali metal salt of dihydric phenol with a dihalobenzenoid compound in the presence of specific liquid organic sulfoxide or sulfone solvents under substantially anhydrous conditions. Catalysts are not necessary for this reaction.

The polymers may also be prepared in a two-step process in which a dihydric phenol is first converted in situ in the primary reaction solvent to the alkali metal salt of the reaction with the alkali metal, the alkali metal hydride, alkali metal hydroxide, alkali metal alkoxide or the alkali metal alkyl compounds. Preferably, the alkali metal hydroxide is employed. After removing the water which is present or formed, in order to secure substantially anhydrous conditions, the dialkali metal salts of the dihydric phenol are admixed and reacted with about stoichiometric quantities of the dihalobenzenoid or dinitrobenzenoid compound.

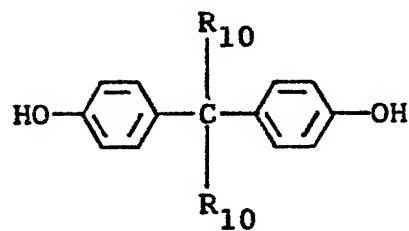
Additionally, the polyethers may be prepared by the procedure described in, for example, U.S. Patent 4,176,222 in which a substantially equimolar mixture of at least one bisphenol and at least one dihalobenzenoid are heated at a temperature of from about 100° to about 400°C with a mixture of sodium carbonate or bicarbonate and a

second alkali metal carbonate or bicarbonate having a higher atomic number than that of sodium.

Further, the polyethers may be prepared by the procedure described in Canadian Patent 847,963 wherein the bisphenol and dihalobenzoid compound are heated in the presence of potassium carbonate using a high boiling solvent such as diphenylsulfone.

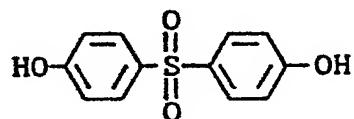
Preferred polyarylene polyethers of this invention are those prepared using the dihydric polynuclear phenols of the following four types, including the derivatives thereof which are substituted with inert substituent groups

(a)

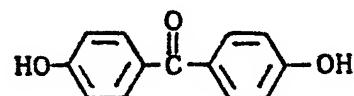


in which the R<sub>10</sub> groups represent independently hydrogen, lower alkyl, aryl and the halogen substituted groups thereof, which can be the same or different;

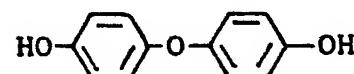
(b)



(c)



(d)

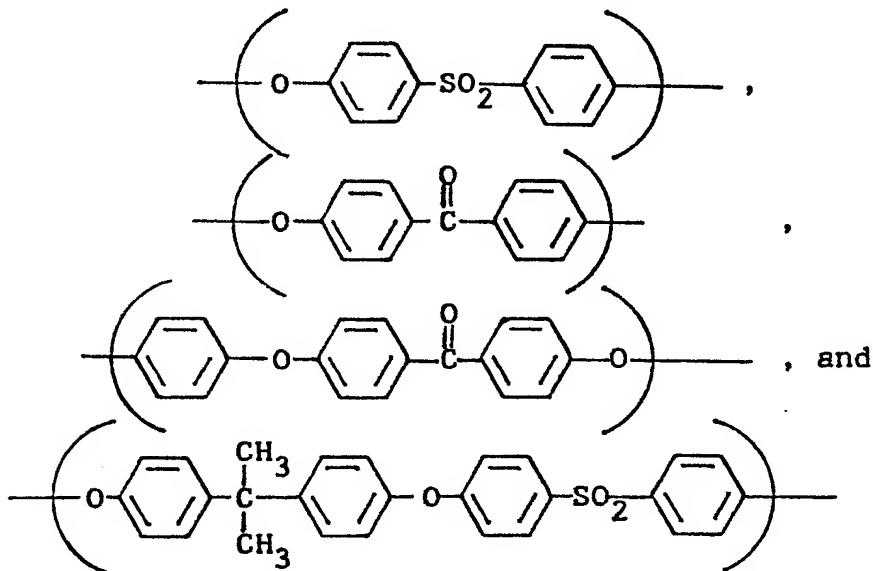


and substituted derivatives thereof.

It is also contemplated in this invention to use a mixture of two or more different dihydric phenols to accomplish the same ends as above. Thus when referred to above the -E- residuum in the polymer structure can actually be the same or different aromatic residua.

The poly(aryl ether)s have a reduced viscosity of from about 0.35 to about 1.5 as measured in an appropriate solvent at an appropriate temperature depending on the particular polyether, such as in methylene chloride at 25°C.

The preferred poly(aryl ether)s have repeating units of the formula:

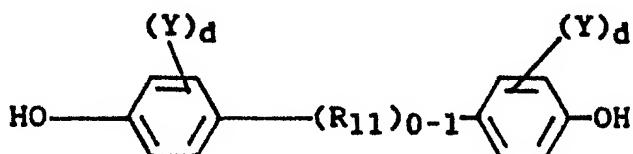


### C. Polyarylates

The polyarylates which are suitable for use in this invention are derived from a dihydric phenol and at least one aromatic dicarboxylic acid and have a reduced viscosity of from about 0.4 to greater

than about 1.0, preferably from about 0.6 to about 0.8 dl/gm, as measured in chloroform (0.5 g/100ml chloroform) or other suitable solvent at 25°C.

A particularly desirable dihydric phenol is of the following formula:



wherein Y is independently selected from, hydrogen, alkyl groups of 1 to 4 carbon atoms, chlorine or bromine, each d, independently, has a value of from 0 to 4, inclusive, and R<sub>11</sub> is a divalent saturated or unsaturated aliphatic hydrocarbon radical, particularly an alkylene or alkylidene radical having from 1 to 6 carbon atoms, or a cycloalkylidene or cycloalkylene radicals having up to and including 9 carbon atoms, O, CO, SO<sub>2</sub>, or S. The dihydric phenols may be used individually or in combination.

The dihydric phenols that may be used in this invention include the following:

- 2,2-bis-4(4-hydroxyphenyl)propane;
- bis-(2-hydroxyphenyl)methane,
- bis-(4-hydroxyphenyl)methane,
- bis-(4-hydroxy-2,6-dimethyl-3-methoxyphenyl)methane,
- 1,1-bis-(4-hydroxyphenyl)ethane,
- 1,2-bis-(4-hydroxyphenyl)ethane,
- 1,1-bis-(4-hydroxy-2-chlorophenyl)ethane,
- 1,3-bis-(3-methyl-4-hydroxyphenyl)ethane,

1,3-bis-(3-methyl-4-hydroxyphenyl)propane,  
2,2-bis-(3-phenyl-4-hydroxyphenyl)propane,  
2,2-bis-(3-isopropyl-4-hydroxyphenyl)  
propane,  
2,2-bis-(2-isopropyl-4-hydroxyphenyl)  
propane,  
2,2-bis-(4-hydroxyphenyl)pentane,  
3,3-bis-(4-hydroxyphenyl)pentane,  
2,2-bis-(4-hydroxyphenyl)heptane,  
1,2-bis-(4-hydroxyphenyl)1,2-bis-(phenyl)-  
propane,  
4,4'-(dihydroxyphenyl)ether,  
4,4'-(dihydroxyphenyl)sulfide,  
4,4'-(dihydroxyphenyl)sulfone,  
4,4'-(dihydroxyphenyl)sulfoxide,  
4,4'-(dihydroxybenzophenone), and  
naphthalene diols

The aromatic dicarboxylic acids that may be used in this invention include terephthalic acid, isophthalic acid, any of the naphthalene dicarboxylic acids and mixtures thereof, as well as alkyl substituted homologs of these carboxylic acids, wherein the alkyl group contains from 1 to about 4 carbon atoms, and acids containing other inert substituents, such as halides, alkyl or aryl ethers, and the like. Acetoxybenzoic acid can also be used. Preferably, mixtures of isophthalic and terephthalic acids are used. The isophthalic acid to terephthalic acid ratio in the mixture is about 0:100 to about 100:0, while the most preferred acid ratio is about 75:25 to about 50:50. Also, from about 0.5 to about 20 percent of aliphatic diacids

containing from 2 to about 10 carbon atoms, such as adipic acid, sebacic acid, and the like may be additionally used in the polymerization reaction.

The polyarylates can be prepared by any of the well known prior art polyester forming reactions, such as the reaction of the acid chlorides of the aromatic dicarboxylic acids with the dihydric phenols; the reaction of the diaryl esters of the aromatic dicarboxylic acids with the dihydric phenols; or the reaction of the aromatic diacids with diester derivatives of the dihydric phenol. These processes are described in, for example, U.S. Patents 3,317,464; 3,948,856; 3,780,148; 3,824,213; and 3,133,898.

The polyarylates are preferably prepared by the process as set forth in U.S. Patent 4,321,355. This process comprises the following steps:

(a) reacting an acid anhydride derived from an acid containing from 2 to 8 carbon atoms with at least one dihydric phenol to form the corresponding diester; and

(b) reacting said diester with at least one aromatic dicarboxylic acid at a temperature sufficient to form the polyarylate, wherein the improvement comprises removing residual acid anhydride after formation of the dihydric phenol diester so that its concentration is less than about 1500 parts per million.

The acid anhydride suitable is derived from an acid containing from 2 to 8 carbon atoms. The preferred acid anhydride is acetic anhydride.

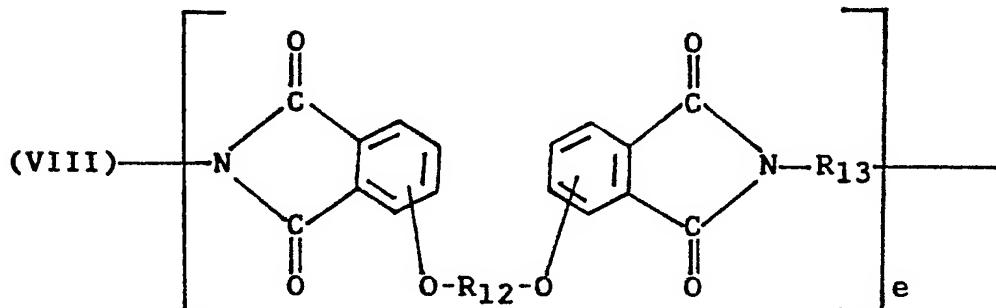
The dihydric phenol is described above.

Generally, the dihydric phenol reacts with the acid anhydride under conventional esterification conditions to form the dihydric phenol diester. The reaction may take place in the presence or absence of a solvent. Additionally, the reaction may be conducted in the presence of a conventional esterification catalyst or in the absence thereof.

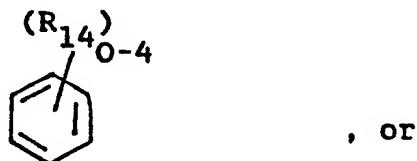
#### D. Polyetherimides

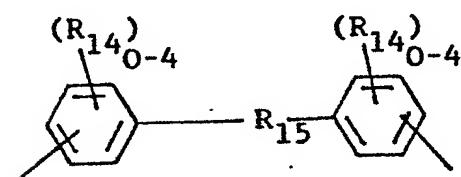
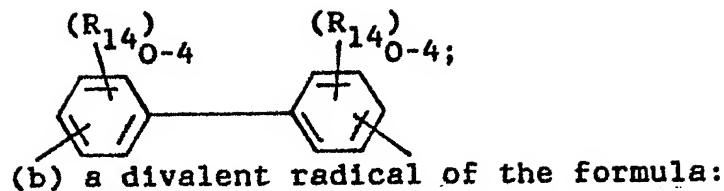
The polyetherimides suitable for use in this invention are well known in the art and are described in, for example, U.S. Patents 3,847,867, 3,838,097 and 4,107,147.

The polyetherimides are of the following formula:



wherein e is an integer greater than 1, preferably from about 10 to about 10,000 or more, -O-R<sub>12</sub>-O- is attached to the 3 or 4 and 3' or 4' positions and R<sub>12</sub> is selected from (a) a substituted or unsubstituted aromatic radical such as

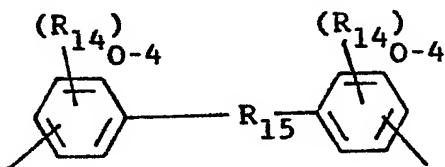




wherein  $R_{14}$  is independently  $C_1$  to  $C_6$  alkyl,  
aryl or halogen and

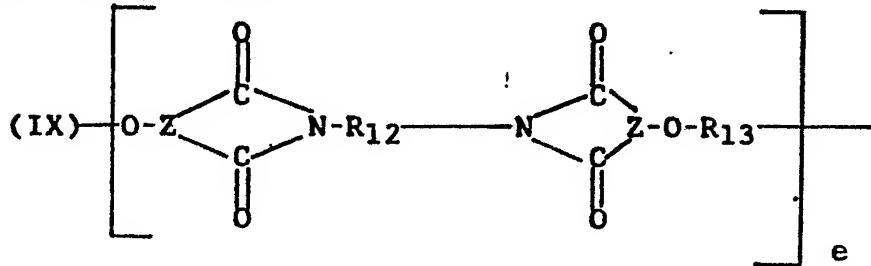


$R_{15}$  is selected from  $-O-$ ,  $-S-$ ,  $-C-$ ,  $-SO_2-$ ,  $-SO-$ , alkylene of 1 to 6 carbon atoms, cycloalkylene of 4 to 8 carbon atoms, alkylidene of 1 to 6 carbon atoms or cycloalkylidene of 4 to 8 carbon atoms,  $R_{13}$  is selected from an aromatic hydrocarbon radical having from 6 to 20 carbon atoms and halogenated derivatives thereof, or alkyl substituted derivatives thereof, wherein the alkyl group contains 1 to 6 carbon atoms, alkylene and cycloalkylene radicals having from 2 to 20 carbon atoms and  $C_2$  to  $C_8$  alkylene terminated polydiorganosiloxane or a divalent radical of the formula

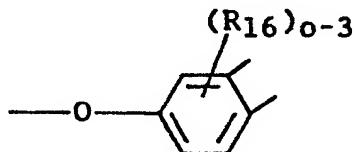


wherein  $R_{14}$  and  $R_{15}$  are as previously defined.

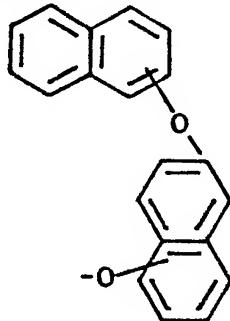
The polyetherimides may also be of the following formula:



wherein  $-O-Z$  is a member selected from



wherein  $R_{16}$  is independently hydrogen, lower alkyl or lower alkoxy \*



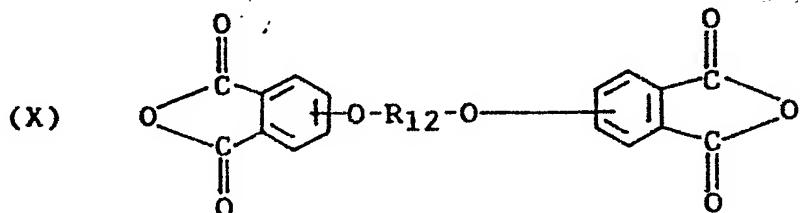
and,

wherein the oxygen may be attached to either ring and located ortho or para to one of the bonds of the imide carbonyl groups,  $R_{12}$  and  $R_{13}$  and  $e$  are as previously defined.

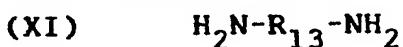
These polyetherimides are prepared by methods well known in the art as set forth in, for example, U.S. Patents 3,833,544, 3,887,588, 4,017,511, 3,965,125 and 4,024,110.

\* The terms "lower alkyl" and "lower alkoxy" mean that the groups contain 1 to 6 carbon atoms.

The polyetherimides of Formula (VIII) can, for example, be obtained by any of the methods well-known to those skilled in the art including the reaction of any aromatic bis(ether anhydride)s of the formula



where  $R_{12}$  is as defined hereinbefore, with a diamino compound of the formula



where  $R_{13}$  is as defined hereinbefore. In general, the reactions can be advantageously carried out employing well-known solvents, e.g., o-dichlorobenzene, m-cresol/toluene, N,N-dimethylacetamide, etc., in which to effect interaction between the dianhydrides and diamines, at temperatures of from about 20 to about 250°C. Alternatively, the polyetherimides can be prepared by melt polymerization of any dianhydrides of Formula (X) with any diamino compound of Formula (XI) while heating the mixture of the ingredients at elevated temperatures with concurrent intermixing. Generally, melt polymerization temperatures between about 200° to 400°C and preferably 230° to 300°C can be employed. Any order of addition of chain stoppers ordinarily employed in melt polymerizations can be employed. The conditions of the reaction and the proportions of ingredients can be varied widely

depending on the desired molecular weight, intrinsic viscosity, and solvent resistance. In general, equimolar amounts of diamine and dianhydride are employed for high molecular weight polyetherimides, however, in certain instances, a slight molar excess (about 1 to 5 mole percent) of diamine can be employed resulting in the production of polyetherimides of Formula I have an intrinsic viscosity  $\eta$  greater than 0.2 deciliters per gram, preferably 0.35 to 0.60, or 0.7 deciliters per gram or even higher when measured in m-cresol at 25°C.

The aromatic bis(ether anhydride)s of Formula (X) include, for example,

2,2-bis[4-(2,3-dicarboxyphenoxy)phenyl]-propane dianhydride;

4,4'-bis(2,3-dicarboxyphenoxy)diphenyl ether dianhydride;

1,3-bis(2,3-dicarboxyphenoxy)benzene dianhydride;

4,4'-bis(2,3-dicarboxyphenoxy)diphenyl sulfide dianhydride;

1,4-bis(2,3-dicarboxyphenoxy)benzene dianhydride;

4,4'-bis(2,3-dicarboxyphenoxy)benzophenone dianhydride;

4,4'-bis(2,3-dicarboxyphenoxy)diphenyl sulfone dianhydride;

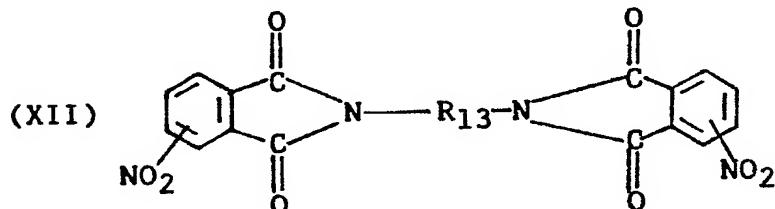
2,2-bis[4-(3,4-dicarboxyphenoxy)phenyl]-propane dianhydride;

4,4'-bis(3,4-dicarboxyphenoxy)diphenyl ether dianhydride;

4,4'-bis(3,4-dicarboxyphenoxy)diphenyl sulfide dianhydride;  
 1,3-bis(3,4-dicarboxyphenoxy)benzene dianhydride;  
 1,4-bis(3,4-dicarboxyphenoxy)benzene dianhydride;  
 4,4'-bis(3,4-dicarboxyphenoxy)benzophenone dianhydride;  
 4-(2,3-dicarboxyphenoxy)-4'-(3,4-dicarboxyphenoxy)diphenyl-2,2-propane dianhydride; etc.  
 and mixtures of such dianhydrides.

The organic diamines of Formula (XI) include, for example, m-phenylenediamine, p-phenylenediamine, 2,2-bis(p-aminophenyl)propane, 4,4'-diaminodiphenyl-methane, 4,4'-diaminodiphenyl sulfide, 4,4'-diamino-diphenyl sulfone, 4,4'-diaminodiphenyl ether, 1,5-diaminonaphthalene, 3,3'-dimethylbenzidine, 3,3'-dimethoxybenzidine,

The polyetherimides of formula (X) may, for example, be prepared by effecting reaction in the presence of a dipolar aprotic solvent of a mixture of ingredients comprising, for instance, (1) a bis(nitrophthalimide) of the general formula:



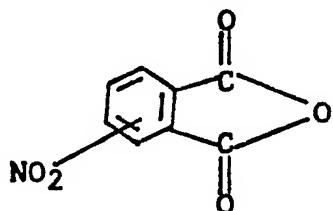
wherein  $R_{13}$  is defined as hereinabove, and (2) an alkali metal salt of an organic compound of the general formula:

(XIII)  $MO-R_{12}-OM$ 

wherein M is an alkali metal and  $R_{12}$  is defined as hereinabove.

The bis(nitrophthalimide) used in preparing the polymer is formed by reacting a diamine of the formula described above,  $NH_2-R_{13}-NH_2$ , with a nitro-substituted aromatic anhydride of the formula:

(XIV)



The molar ratio of diamine to anhydride should ideally be about 1:2 respectively. The initial reaction product is a bis(amide-acid) which is subsequently dehydrated to the corresponding bis(nitrophthalimide).

The diamines are described, supra.

The preferred nitrophthalic anhydrides useful in the present invention are 3-nitrophthalic anhydride, 4-nitrophthalic anhydride and mixtures thereof. These reactants are commercially available in reagent grade. They may also be prepared by the nitration of phthalic anhydride using procedures described in Organic Syntheses, Collective Vol. I, Wiley (1948), page 408. Certain other closely related nitroaromatic anhydrides may also be used in the reaction and are illustrated for example by 2-nitronaphthalic anhydride, 1-nitro-2,3-naphthalene-dicarboxylic anhydride and 3-methoxy-6-nitrophthalic anhydride, and the like.

With reference to the alkali metal salts of formula (XIII) among the divalent carbocyclic aromatic radicals which  $R_{12}$  may represent (mixtures of such radicals are also included) are, for instance, divalent aromatic hydrocarbon radicals of from 6 to 20 carbon atoms, such as phenylene, biphenylene, naphthylene, etc. Included are residues of, e.g. hydroquinone, resorcinol, chlorohydroquinone, etc. In addition,  $R_{12}$  may be a residue of a dihydroxyl diarylene compound in which the aryl nuclei are joined by either an aliphatic group, a sulfoxide group, sulfonyl group, sulfur, carbonyl group, oxygen, etc. Typical of such diarylene compounds are the following:

2,4-dihydroxydiphenylmethane;  
bis(2-hydroxyphenyl)methane;  
2,2-bis(4-hydroxyphenyl)propane;  
bis(4-hydroxyphenyl)methane;  
bis(4-hydroxy-5-nitrophenyl)methane;  
bis(4-hydroxy-2,6-dimethyl-3-methoxy-phenyl)methane;  
1,1-bis(4-hydroxyphenyl)ethane;  
1,2-bis(4-hydroxyphenyl)ethane;  
1,1-bis(4-hydroxy-2-chlorophenyl)ethane;  
1,1-bis(2,5-dimethyl-4-hydroxyphenyl)ethane;  
1,3-bis(3-methyl-4-hydroxyphenyl)propane;  
2,2-bis(3-phenyl-4-hydroxyphenyl)propane;  
2,2-bis(3-isopropyl-4-hydroxyphenyl)propane;  
2,2-bis(4-hydroxynaphthyl)propane;  
hydroquinone;  
naphthalene diols;  
bis(4-hydroxyphenyl)ether;

bis(4-hydroxyphenyl)sulfide;  
bis(4-hydroxyphenyl)sulfone; and the like.

When dialkali metal salts of formula (XIII) are used with the compound illustrated by formula (XII), the ingredients are advantageously present in an equal molar ratio for optimum molecular weight and properties of the polymer. Slight molar excesses, e.g., about 0.001 to 0.10 molar excess of either the dinitro-substituted organic compound or of the dialkali metal salt of formula (XIII) may be employed. When the molar ratios are approximately equal, the polymer is substantially terminated by  $a = Z-NO_2$  at one end and a phenolic group at the other end. If there is a molar excess of one compound, that particular terminal group will predominate.

The conditions of reaction whereby the alkali-metal salt of formula (XIII) is reacted with the dinitro-substituted organic compound of formula (XII) can be varied widely. Generally, temperatures of the order of about 25 to about 150°C are advantageously employed, although it is possible to employ lower or higher temperature conditions depending on the ingredients used, the reaction product sought, time of reaction, solvent employed, etc. In addition to atmospheric pressure, superatmospheric pressures and subatmospheric pressures may be employed depending upon the other conditions of reaction, the ingredients used, the speed at which it is desired to effect reaction, etc.

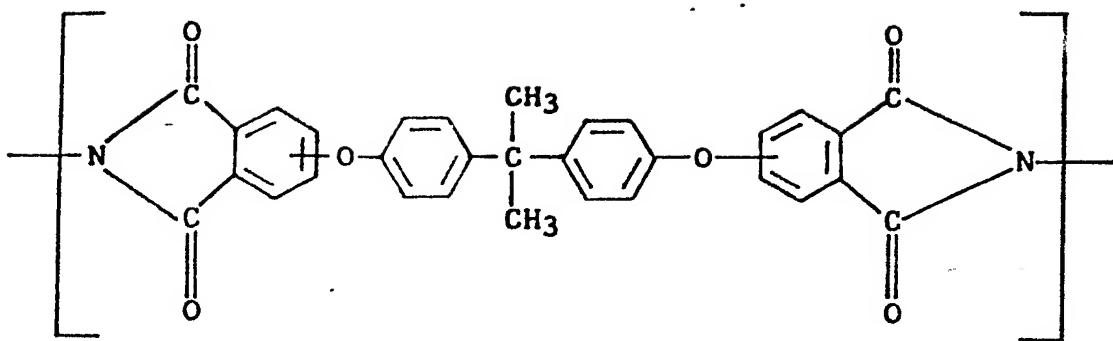
The time of reaction also can be varied widely depending on the ingredients used, the

temperature, the desired yield, etc. It has been found that times varying from about 5 minutes to as much as 30 to 40 hours are advantageously employed to obtain the maximum yield and desired molecular weight. Thereafter the reaction product can be treated in the appropriate manner required to effect precipitation and/or separation of the desired polymeric reaction product. Generally, common solvents such as alcohols (e.g. methanol, ethanol, isopropyl alcohol, etc.) and aliphatic hydrocarbons (e.g. pentane, hexane, octane, cyclohexane, etc.) may be employed as precipitants for this purpose.

It is important that the reaction between the dinitro-substituted organic compound of formula V and the alkali-metal salt of formula VI (mixtures of such alkali-metal salts can also be used) be carried out in the presence of a dipolar aprotic solvent.

The polymerization is performed under anhydrous conditions usually using dipolar aprotic solvents such as dimethylsulfoxide which are added in varying amounts depending upon the particular polymerization. A total quantity of solvent, dipolar aprotic solvent or mixture of such solvent with an aromatic solvent sufficient to give a final solution containing 10 to 20% by weight of polymer is preferably employed.

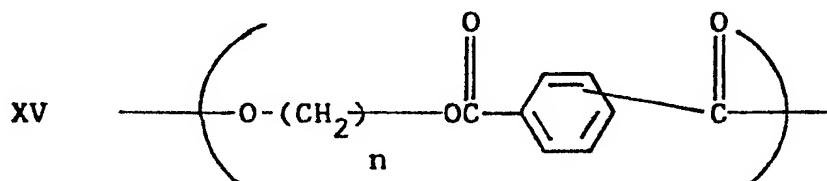
The preferred polyetherimides include those having repeating units of the following formula:



The Crystalline Polymers

A. Polyesters

The polyesters which are suitable for use herein are derived from an aliphatic or cycloaliphatic diol, or mixtures thereof, containing from 2 to about 10 carbon atoms and at least one aromatic dicarboxylic acid. The polyesters which are derived from an aliphatic diol and an aromatic dicarboxylic acid have repeating units of the following general formula:



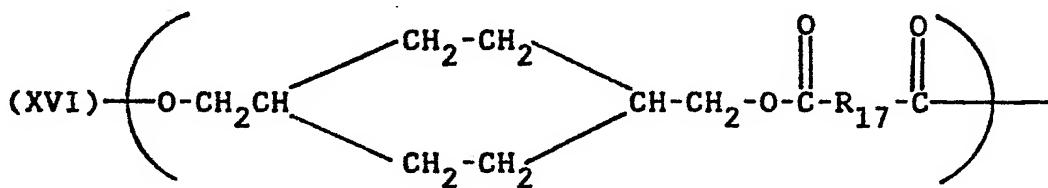
wherein n is an integer of from 2 to 10.

Preferred polyesters include poly(ethylene terephthalate) and poly(butylene terephthalate).

Also contemplated herein are the above polyesters with minor amounts, e.g., from 0.5 to about 2 percent by weight, of units derived from aliphatic acids and/or aliphatic polyols, to form copolyesters. The aliphatic polyols include glycols, such as poly(ethylene glycol). These can

be made following the teachings of, for example, U.S. Patents 2,465,319 and 3,047,539.

The polyesters which are derived from a cycloaliphatic diol and an aromatic dicarboxylic acid are prepared by condensing either the cis - or trans-isomer (or mixtures thereof) of, for example, 1,4-cyclohexanedimethanol with an aromatic dicarboxylic acid so as to produce a polyester having recurring units of the following formula:

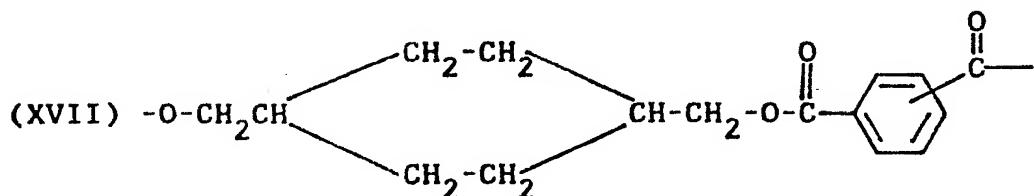


wherein the cyclohexane ring is selected from the cis- and trans- isomers thereof and R<sub>17</sub> represents an aryl radical containing 6 to 20 carbon atoms and which is the decarboxylated residue derived from an aromatic dicarboxylic acid.

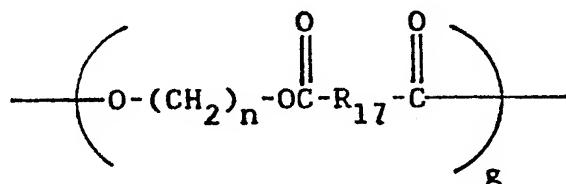
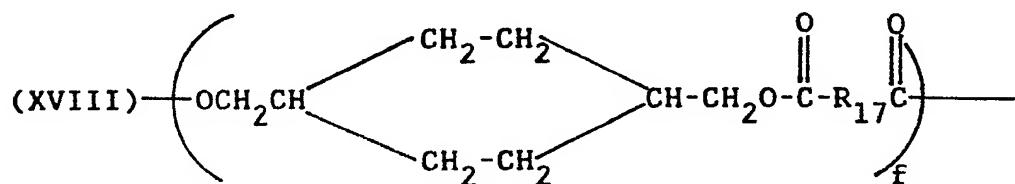
Examples of aromatic dicarboxylic acids indicated by R<sub>17</sub> in formula IX, are isophthalic or terephthalic acid, 1,2-di(p-carboxyphenyl)ethane, 4,4'-dicarboxydiphenyl ether, etc., and mixtures of these. All of these acids contain at least one aromatic nucleus. Fused rings can also be present, such as in 1,4-or 1,5-naphthalenedicarboxylic acids. The preferred dicarboxylic acids are terephthalic acid or a mixture of terephthalic and isophthalic acids.

A preferred polyester may be derived from the reaction of either the cis-or trans-isomer (or a mixture thereof) of 1,4-cyclohexanedimethanol with a

mixture of isophthalic and terephthalic acids. These polyesters have repeating units of the formula:



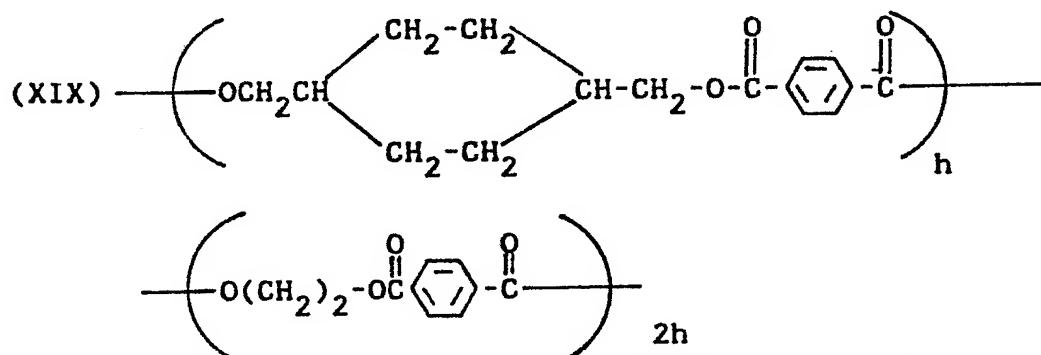
Another preferred polyester is a copolyester derived from a cyclohexane dimethanol, an alkylene glycol and an aromatic dicarboxylic acid. These copolyesters are prepared by condensing either the cis- or trans-isomer (or mixtures thereof) of, for example, 1,4-cyclohexanedimethanol and an alkylene glycol with an aromatic dicarboxylic acid so as to produce a copolyester having repeating units of the following formula:



wherein the cyclohexane ring is selected from the cis- and trans- isomers thereof, R<sub>17</sub> is as

previously defined, n is an integer of 2 to 10, the f units comprise from about 10 to about 90 percent by weight and the g units comprise from about 10 to about 90 percent by weight.

The preferred copolyester may be derived from the reaction of either the cis- or trans-isomer (or mixtures thereof) of 1,4-cyclohexanedimethanol and ethylene glycol with terephthalic acid in a molar ratio of 1:2:3. These copolymers have repeating units of the following formula:



wherein h can be 10 to 10,000. Block as well as random copolymers are possible.

The polyesters as described herein are either commercially available or can be produced by methods well known in the art, such as those set forth in, for example, U.S. Patent 2,901,466.

The polyesters used herein have an intrinsic viscosity of from about 0.4 to about 2.0 dl/g. as measured in a 60:40 phenol/tetrachloroethane mixture or similar solvent at 23 to 30°C.

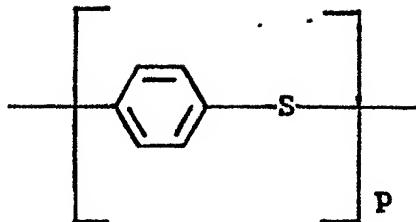
#### B. Poly(arylene sulfide)

The poly(arylene sulfide)s which are

suitable for use herein are solid, have a melting point of at least about 150°F. and are insoluble in common solvents. Such resins can be conveniently prepared by the process disclosed in, for example, U.S. Pat. No. 3,354,129. Briefly, the process comprises the reaction of an alkali metal sulfide and a polyhalo ring-substituted aromatic compound in the presence of a suitable polar organic compound, as for example, the reaction of sodium sulfide with dichlorobenzene in the presence of N-methyl-2-pyrrolidone to form poly(phenylene-sulfide).

The resulting polymer contains the aromatic nucleus of the polyhalo-substituted monomer coupled in repeating units predominantly through a sulfur atom. The polymers which are preferred for use according to this invention are those polymers having the repeating unit  $-R_{23}-S-$  where  $R_{23}$  is phenylene, biphenylene, naphthylene, or a lower alkyl-substituted derivative thereof. By lower alkyl is meant alkyl groups having one to six carbon atoms such as methyl, propyl, isobutyl, n-hexyl and the like.

The preferred poly(arylene sulfide) is poly(phenylene sulfide), a crystalline polymer with a repeating structural unit comprising a para-substituted benzene ring and a sulfur atom which may be described by the following formula, where p has a value of at least about 50.



Suitable poly(phenylene sulfide) compositions are available commercially under the trade name Ryton of the Phillips Petroleum Company. Preferably, the poly(phenylene sulfide) component has a melt flow index, measured at 600°F. using a 5 Kg. weight and a standard orifice, within the range of from about 10 to about 7000 dg./min..

The term poly(arylene sulfide) is meant to include not only homopolymers but also arylene sulfide copolymers, terpolymers and the like.

### C. Polyamides

The polyamide polymers which may be used herein are well known in the art. The polyamide polymers include homopolymers as well as copolymers. These polymers may be formed by conventional methods from the condensation of bifunctional monomers, by the condensation of diamines and dibasic acids, as well as by addition polymerization. Numerous combinations of diacids, such as carbonic acid, oxalic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, dodecanedioic acid, isophthalic acid, terephthalic acid, and the like, diamines, such as hydrazine, ethylenediamine, hexamethylenediamine, 1,8-octanediamine, piperazine, and the like, and amino acids are possible. The chains between functional groups in the reactants

may comprise linear or branched aliphatic hydrocarbons, or alicyclic or aromatic rings. They may also contain hetero atoms such as oxygen, sulfur, and nitrogen. Secondary diamines lead to the formation of N-substituted polyamides

Also, included herein are the aromatic polyamide polymers which are aromatic in both the diamine and the dibasic acid. The dibasic acids include terephthalic acid, isophthalic acid, phthalic acid, and the like. The aromatic diamines include o-phenylenediamine, 2,4-diaminotoluene, 4,4'-methylenedianiline, and the like.

The polyamide polymers are prepared by methods well known in the art, such as by direct amidation which is the reaction of amine groups with carboxyls accompanied by elimination of water; low temperature polycondensation of diamines and diacid chlorides, ring-opening polymerization, addition of amines to activated double bonds, polymerization of isocyanates and reaction of formaldehyde with dinitriles.

The polyamide polymers include polyhexamethylene-adipamide, i.e., nylon 6,6; poly( $\epsilon$ -caprolactam), i.e., nylon-6; polypropiolactam, i.e., nylon-3; poly(pyrrolidin-2-one), i.e., nylon-4; poly( $\omega$ -enanthamide), i.e., nylon-7; polycapryllactam, i.e., nylon-8; poly( $\omega$ -pelargonamide), i.e., nylon-9; poly(11-aminodecanoic acid), i.e., nylon-10; poly( $\omega$ -undecaneamide), i.e., nylon-11; polyhexamethyleneterephthalamide, i.e., nylon-6,T, nylon 6,10, and the like

Other Additives

Other additives which may be used in combination with the thermoplastic polymers include mineral fillers such as carbonates including chalk, calcium carbonate, calcite and dolomite; silicates including mica, talc, wollastonite; silicon dioxide; glass spheres; glass powders; aluminum; clay; quartz; and the like. Additional additives include reinforcements such as glass fibers, carbon fibers, polyamides, silicon carbide, etc., pigments, such as titanium dioxide; thermal stabilizers such as zinc oxide; ultraviolet light stabilizers, plasticizers, and the like.

The mineral fillers and reinforcements may be used in amounts of up to about 40, preferably up to about 30 weight percent. The pigments are generally used in amounts of up to about 10 weight percent. The stabilizers are used in stabilizing amounts to stabilize the composition for the effect desired.

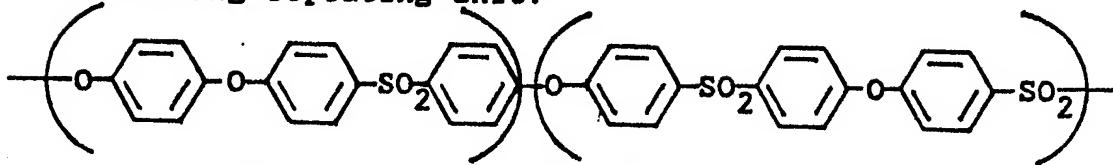
Additionally, nucleation additives such as sodium benzoate, various fillers, Cab-o-sil, and the like can be added to improve the crystallization rate so that injection molded articles will attain higher levels of crystallinity.

EXAMPLES

The following examples serve to give specific illustrations of the practice of this invention but they are not intended in any way to limit the scope of this invention.

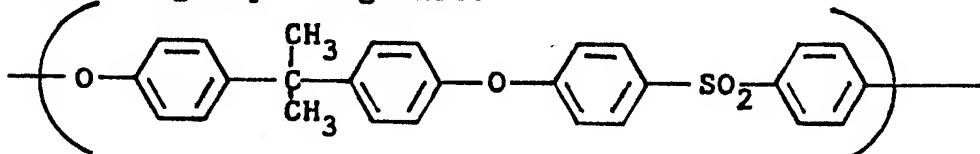
The following designations used in the Examples have the following meaning:

Polyarylethersulfone: A polymer having the following repeating unit:



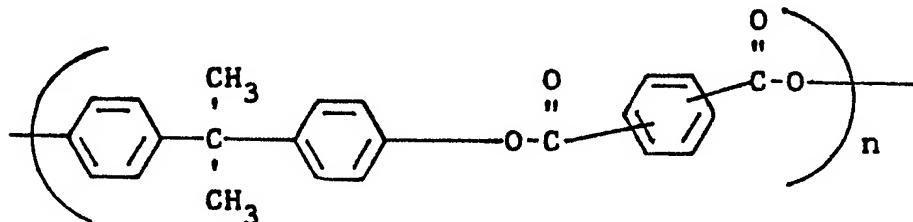
The polymer has a reduced viscosity of 0.61 dl/g as measured in N-methyl-pyrrolidinone (0.2 g/100 ml) at 25°C.

Polysulfone: A polymer having the following repeating unit:



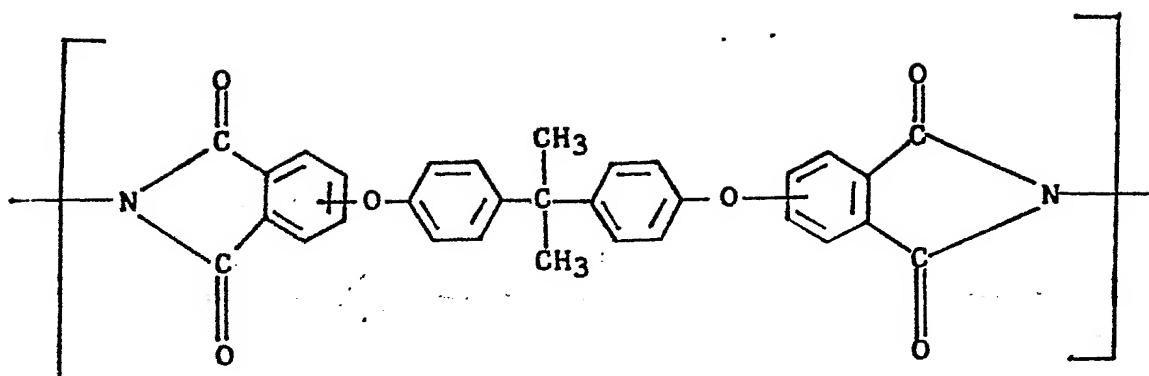
This polymer has a reduced viscosity of 0.47 dl/g as measured in chloroform (0.1 g/100 ml) at 25°C.

Polyarylate: A polymer having a repeat unit of formula:



having a reduced viscosity of 0.66 as measured in p-chlorophenol, 0.2 g/100 ml at 49°C (ARDEL® D-100 obtained from Union Carbide Corp.)

Polyetherimide: A polymer having a repeat unit of the formula:



This polymer has a reduced viscosity of 0.51 as measured in chloroform (0.5 g. per 100 ml) at 25°C.

Controls A and B

Polyarylethersulfone and Polysulfone were injection molded into 1/8 inch thick tensile specimens on an Arburg reciprocating screw injecting molding machine at about 720°F, immersed in water for 16 hours, and completely submerged in molten solder at 420°F for 60-120 seconds (simulation of VPS exposure). The latter represents a rigorous thermal exposure which resulted in bubbling, foaming, and distortion of the test specimens.

The test specimens were measured for the following properties: tensile modulus, tensile strength and percent elongation according to ASTM D-638, tensile impact according to ASTM D-1822; flexural strength and modulus according to ASTM D-638 and heat distortion temperature according to ASTM D-648.

Table I

<u>Test Property</u>	<u>Polyaryl- ethersulfone</u>	<u>Poly- sulfone</u>
Tensile Strength (psi)	12,000	10,200
Tensile Modulus (psi)	385,000	360,000
% Elongation at Break	40	50-100
Flexural Strength (psi)	16,100	15,400
Flexural Modulus (psi)	399,000	390,000
HDT @ 264 psi (°C)	204°C	174°C

Example 1

A poly(phenylene sulfide) resin (Ryton P-4, Phillips Chemical Co., Houston, TX) was placed in a pan to a depth of 2 inches. The pan was then placed in a circulating air oven at 240°C for 17 hours for advancement. After advancing, the resin had a melt flow of 1.4 dg/min (as measured according to ASTM D-1238 at 300°C, 44 psi). Thirty-five parts by weight of this poly(phenylene sulfide) was then combined with 35 parts by weight of Polysulfone, 28 parts by weight of fiberglass (Owens-Corning OCF-497B) and 2 parts by weight zinc oxide in a single screw one-inch diameter extruder (L/D = 20) equipped with a Maddox mixing head at about 310°C and molded into ASTM specimens. The specimens were tested as in Controls A and B.

Example 2

35 parts by weight of Polyarylether-sulfone, 35 parts by weight of poly(ethylene terephthalate) (Cleartuf 7202A, obtained from Goodyear Tire and Rubber Co.), 20 parts by weight of fiberglass (OCF-497B, Owens-Corning Corp., Anderson,

SC) and 10 parts by weight of talc (reagent grade, Mallinckrodt, Inc., Paris, KY) were blended in a single screw one-inch diameter extruder (L/D = 20) equipped with a Maddox mixing head at about 275°C. and molded into ASTM specimens. The specimens were tested as in Controls A and B.

Example 3

35 parts by weight of Polysulfone, 35 parts by weight of the poly(ethylene terephthalate) of Example 2, 20 parts by weight of fiberglass (OCF-497B, Owens-Corning Corp., Anderson, SC) and 10 parts by weight of talc (reagent grade, Mallinckrodt, Paris, KY) were mixed in a single screw one-inch diameter extruder (L/D = 20) equipped with a Maddox mixing head at about 275°C. into ASTM specimens. The specimens were tested as in Controls A and B.

Example 4

A poly(phenylene sulfide) resin (Ryton P-4 obtained from Phillips Chemical Co., Houston, TX) was placed in a pan to a depth of 2 inches. The pan was then placed in a circulating air oven at 240°C for 17 hours to advance it. After advancing the resin had a melt flow of 1.4 dg/min as measured according to ASTM D-1238 at 300°C., 44 psi. Thirty-five parts by weight of the poly(phenylene sulfide) was blended with 35 parts by weight of Polyarylethersulfone, 28 parts by weight of muscovite mica (English Mica Co., Stamford, CT) and 2 parts by weight zinc oxide in a single screw one-inch diameter extruder (L/D = 20) equipped with

a Maddox mixing head at about 310°C into ASTM specimens. The specimens were tested as in Controls A and B.

Example 5

Thirty-five parts by weight of the advanced poly(phenylene sulfide) resin of Example 4 was blended with 35 parts by weight of Polyarylethersulfone, 28 parts by weight of fiberglass (Owens-Corning OCF-497B) and 2 parts by weight zinc oxide in a single screw one-inch diameter extruder ( $L/D = 20$ ) equipped with a Maddox mixing head at about 310°C into ASTM specimens. The specimens were tested as in Controls A and B.

Table II  
Formulations of Examples 1 to 5

<u>Ingredients</u>	<u>Examples</u>				
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
Poly(phenylene sulfide)	35%	-	-	35%	35%
Polysulfone	35%	-	35%	-	-
Polyarylethersulfone	-	35%	-	35%	35%
Poly(ethylene terephthalate)	-	35%	35%	-	-
Fiberglass	28%	20%	20%	-	28%
Talc	-	10%	10%	-	-
Zinc Oxide	2%	-	-	2%	2%
Mica	-	-	-	28%	-

Table III depicts the physical properties of the resins of Examples 1 to 5.

Table III

	<u>Examples</u>			
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>
Tensile Strength	15,500	13,200	14,300	10,600
Tensile Modulus	1,460,000	1,040,000	1,040,000	1,540,000
% Elongation to Break	1.41	1.54	1.82	0.89
Flexural Strength	23,600	19,000	20,200	16,700
Flexural Modulus	1,250,000	1,110,000	1,130,000	1,340,000
HDT @ 264 psi	179.0°C	205°C	182°C	200°C
				209°C

SOLDER TEST

The formulations from Table II were injection molded into 1/8 inch thick ASTM type I tensile bars on an Arburg reciprocating screw injection molding machine. The tensile specimens were immersed in water at about 25°C for 16 hours and then directly immersed in molten solder at 420°F for 60, 90, and 120 seconds to simulate typical VPS exposure conditions. No distortion, bubbling, or foaming was observed.

Example 6

Fifty parts by weight of Polyetherimide, 30 parts by weight of the advanced poly(phenylene sulfide) resin of Example 4 and 20 parts by weight of the fiberglass of Example 5 were blended as described in Example 5 and injection molded and tested as described in the SOLDER TEST.

No distortion, bubbling, or foaming of the test specimens was observed.

Control C

Eighty parts by weight of Polyetherimide and 20 parts by weight of the fiberglass of Example 5 were blended as described in Example 5 and injection molded and tested as described in the SOLDER TEST.

The specimens showed foaming.

Example 7

Fifty parts by weight of Polyarylate and 50 parts by weight of nylon 6,6(Zytel obtained from

E. I. duPont De D'Nemours & Co.) were blended as described in Example 5 and injection molded and tested as described in the SOLDER TEST.

No distortion, bubbling, or foaming of the test specimens was observed.

Control D

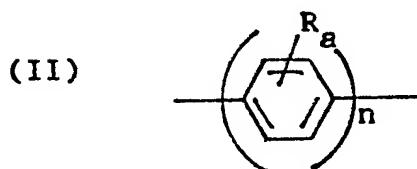
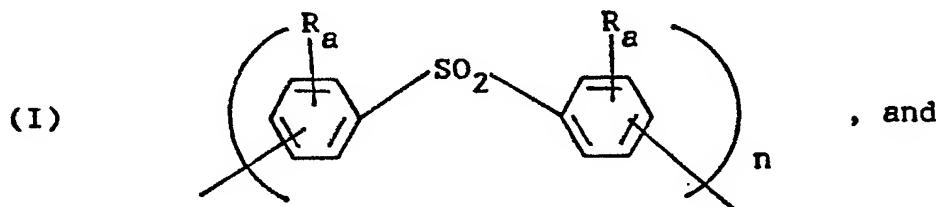
Polyarylate was injection molded and tested as described in the SOLDER TEST.

The specimens showed distortion.

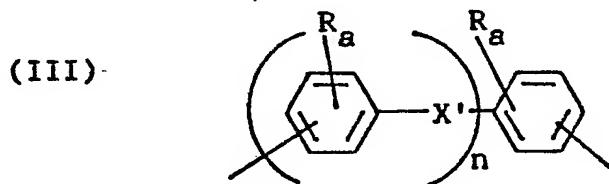
WHAT IS CLAIMED IS:

1. A composition suitable for use as an insulating material in an electrical device comprising from about 35 to about 65 weight percent of an amorphous polymer selected from a polyarylethersulfone, a polyarylether, a polyetherimide, or a polyarylate and from about 65 to about 35 weight percent of a crystalline polymer selected from a poly(arylene sulfide), a polyester or a polyamide.

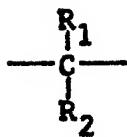
2. A composition as defined in claim 1 wherein the polyarylethersulfone contains units of the following formula:



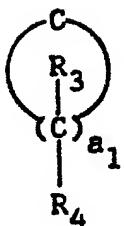
and/or



wherein R is independently hydrogen, C<sub>1</sub> to C<sub>6</sub> alkyl or C<sub>4</sub> to C<sub>8</sub> cycloalkyl, X' is independently

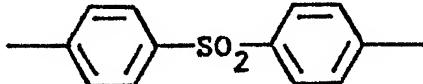


wherein R<sub>1</sub> and R<sub>2</sub> are independently hydrogen or C<sub>1</sub> to C<sub>9</sub> alkyl, or

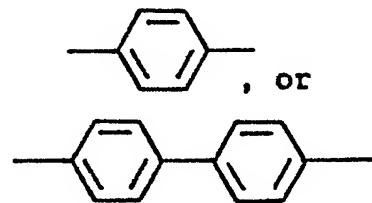


wherein R<sub>3</sub> and R<sub>4</sub> are independently hydrogen or C<sub>1</sub> to C<sub>8</sub> alkyl, and n is an integer of 3 to 8; and n is independently an integer of 1 to 3 and wherein the ratio of unit (I) to the sum of units (II) and/or (III) is greater than 1, wherein the units are attached to each other by an -O- bond.

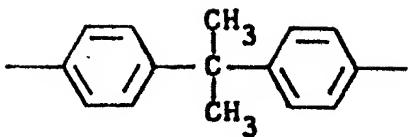
3. A composition as defined in claim 2 wherein in the polyarylethersulfone, unit (I) has the formula:



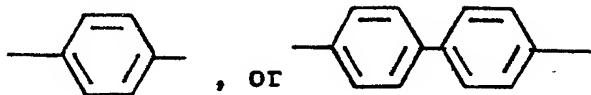
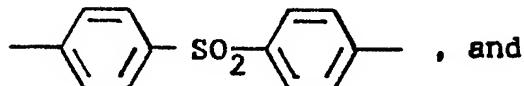
4. A composition as defined in one or both of the claims 2-3, wherein in the polyarylethersulfone, unit (II) has the formula:



5. A composition as defined in one or more of the claims 2-4, wherein in the polyarylethersulfone, unit (III) has the formula:

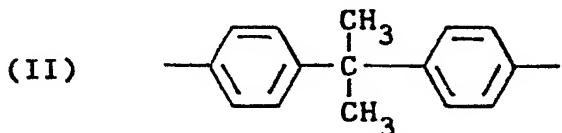
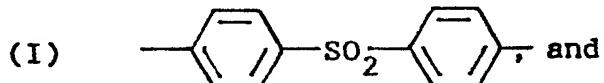


6. A composition as defined in claim 2,  
wherein the polyarylethersulfone contains recurring  
units of the formula:



said units being attached to each other or by an -O-  
bond.

7. A composition as defined in claim 1,  
wherein the polyarylethersulfone contains recurring  
units of the formula:

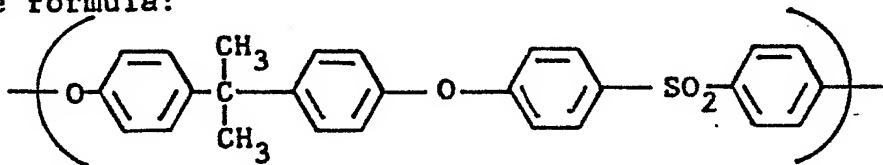


8. A composition as defined in claim 1  
wherein the poly(aryl ether) contains recurring  
units of the following formula:

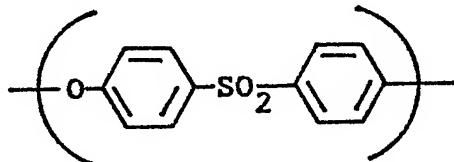
-O-E-O-E'-

wherein E is the residuum of a dihydric phenol, and E' is the residuum of a benzenoid compound having an inert electron withdrawing group in at least one of the positions ortho and para to the valence bonds; both of said residua are valently bonded to the ether oxygens through aromatic carbon atoms.

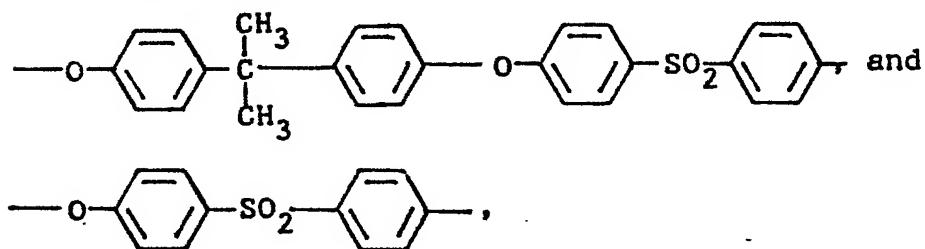
9. A composition as defined in claim 8 wherein the poly(aryl ether) has repeating units of the formula:



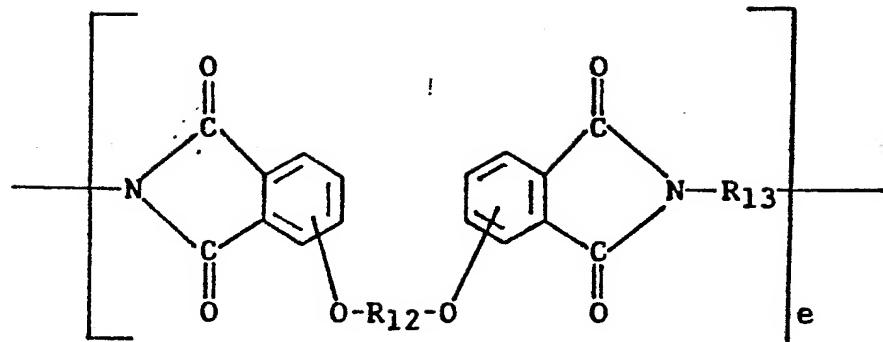
10. A composition as defined in claim 8 wherein the poly(aryl ether) has repeating units of the formula:



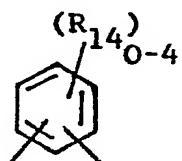
11. A composition as defined in claim 8 wherein the poly(aryl ether) contains units of the following formula:



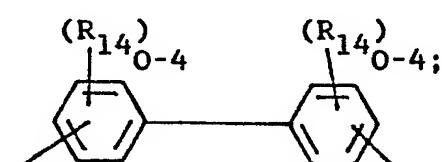
12. A composition as defined in claim 1, wherein the thermoplastic polymer is a polyetherimide, e.g. polyetherimide polymers of the following formula:



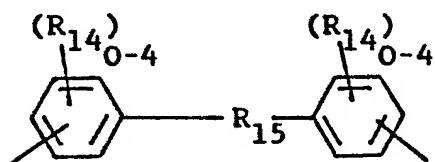
wherein e is an integer greater than 1, preferably from about 10 to about 10,000 or more,  $-O-R_{12}-O-$  is attached to the 3 or 4 and 3' or 4' positions and  $R_{12}$  is selected from (a) a substituted or unsubstituted aromatic radical such as



, or

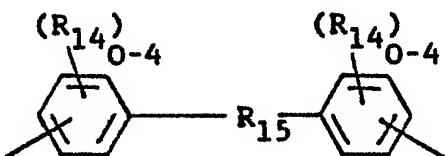


(b) a divalent radical of the formula:



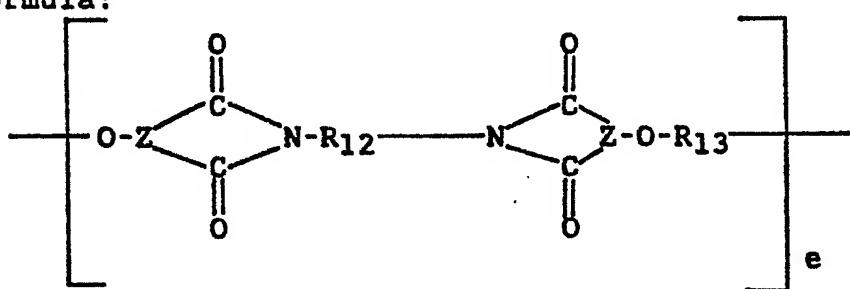
wherein  $R_{14}$  is independently  $C_1$  to  $C_6$  alkyl, aryl or halogen and

$R_{15}$  is selected from  $-O-$ ,  $-S-$ ,  $-C-$ ,  $-SO_2-$ ,  $-SO-$ , alkylene of 1 to 6 carbon atoms, cycloalkylene of 4 to 8 carbon atoms, alkylidene of 1 to 6 carbon atoms or cycloalkylidene of 4 to 8 carbon atoms,  $R_{13}$  is selected from an aromatic hydrocarbon radical having from 6 to 20 carbon atoms and halogenated derivatives thereof, or alkyl substituted derivatives thereof, wherein the alkyl group contains 1 to 6 carbon atoms, alkylene and cycloalkylene radicals having from 2 to 20 carbon atoms and  $C_2$  to  $C_8$  alkylene terminated polydiorganosiloxane or a divalent radical of the formula

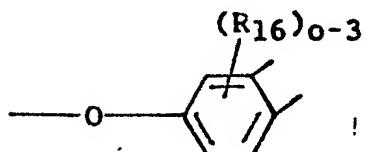


wherein  $R_{14}$  and  $R_{15}$  are as previously defined,

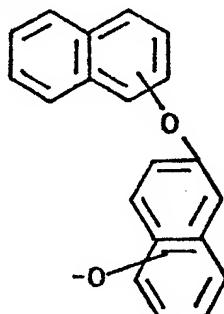
or the polyetherimide is of the following formula:



wherein  $-O-Z$  is a member selected from



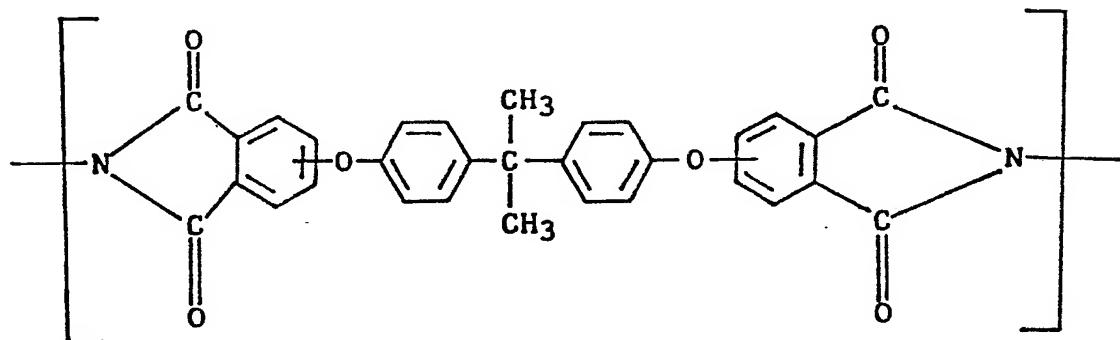
wherein R<sub>16</sub> is independently hydrogen, lower alkyl or lower alkoxy



and,

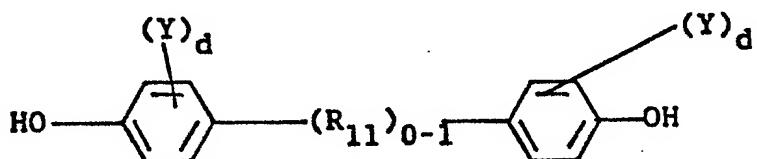
wherein the oxygen may be attached to either ring and located ortho or para to one of the bonds of the imide carbonyl groups, R<sub>12</sub> and R<sub>13</sub> and e are as defined in claim 13,

or the polyetherimide has repeating units of the following formula:



13. A composition as defined in claim 1 wherein the thermoplastic polymer is a polyarylate, e.g. a polyarylate derived from a dihydric phenol and at least one aromatic dicarboxylic acid.

14. A composition as defined in claim 13 wherein the dihydric phenol is of the following formula:

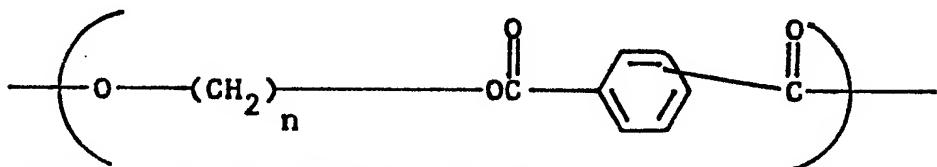


wherein Y is independently selected from hydrogen, alkyl groups of 1 to 4 carbon atoms, chlorine or bromine, each d, independently, has a value of from 0 to 4, inclusive, and R<sub>11</sub> is a divalent saturated or unsaturated aliphatic hydrocarbon radical, particularly an alkylene or alkylidene radical having from 1 to 6 carbon atoms, or a cycloalkylidene or cycloalkylene radical having up to and including 9 carbon atoms, O, CO, SO<sub>2</sub>, or S.

15. A composition as defined in one or both of the claims 13-14, wherein the aromatic dicarboxylic acid is terephthalic acid, isophthalic acid, any of the naphthalene dicarboxylic acids and mixtures thereof, as well as alkyl substituted homologs of these carboxylic acids, wherein the alkyl group contains from 1 to about 4 carbon atoms, and acids containing halides, alkyl or aryl ethers.

16. A composition as defined in one or more of the claims 13-15, wherein the polyarylate is derived from bisphenol A and terephthalic acid or isophthalic acid, or mixtures thereof.

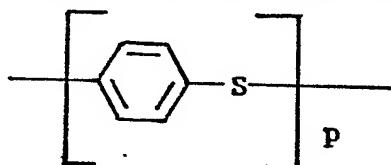
17. A composition as defined in claim 1, wherein the thermoplastic polymer is a polyester, e.g. a polyester with repeating units of the general formula:



wherein  $n$  is an integer of from 2 to 10.

18. A composition as defined in claim 1 wherein the polyester is poly(ethylene terephthalate).

19. A composition as defined in claim 1 wherein the thermoplastic polymer is poly(arylene sulfide), e.g. of the following formula:



wherein  $p$  has a value of at least about 50.

20. A composition as defined in claim 1, wherein the thermoplastic polymer is a polyamide, e.g. selected from nylon 6,6, nylon 6, or nylon 6,10.

21. A composition as defined in one or more of the claims 1-20, which contains from about 40 to about 60 weight percent of the amorphous polymer and from about 60 to about 40 weight percent of the crystalline polymer.

22. A composition as defined in one or more of the claims 1-7, comprising from about 35 to about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a poly(arylene sulfide), e.g. poly(phenylene sulfide).

23. A composition as defined in one or more of the claims 1-7, comprising from about 35 to about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a polyester, e.g. poly(ethylene terephthalate).

24. A composition as defined in one or more of the claims 1, 8-11, comprising from about 35 to about 65 weight percent of a polyarylether and from about 65 to about 35 weight percent of a poly(arylene sulfide).

25. A composition as defined in one or more of the claims 1, 8-11, comprising from about 35 to about 65 weight percent of a polyarylether and from about 65 to about 35 weight percent of a polyester, e.g. poly(ethylene terephthalate).

26. A molded electrical device comprising an electrically conductive pathway and an insulating material, the device being capable of interconnecting with external circuitry, said insulating material comprising from about 35 to about 65 weight percent of an amorphous polymer selected from a polyarylethersulfone, a polyarylether, a polyetherimide, or a polyarylate and from about 65 to about 35 weight percent of a crystalline polymer selected from a poly(arylene sulfide), a polyester or a polyamide.

27. A device as in claim 26 wherein the insulating material comprises from about 35 to about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a poly(arylene sulfide).

28. A device as defined in claim 26 wherein the insulating material comprises from about 35 to about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a polyester.

29. A device as defined in claim 26, wherein the insulating material comprises from about 35 to about 65 weight percent of a polyarylether and from about 65 to about 35 weight percent of a poly(arylene sulfide).

30. A device as defined in claim 26, wherein the insulating material comprises from about 35 to about 65 weight percent of a polyarylether and from about 65 to about 35 weight percent of a polyester.

31. A circuit board substrate made from a composition comprising from about 35 to about 65 weight percent of an amorphous polymer selected from a polyarylethersulfone, a polyarylether, a polyetherimide, or a polyarylate and from about 65 to about 35 weight percent of a crystalline polymer selected from a poly(arylene sulfide), a polyester or a polyamide.

32. A substrate as defined in claim 31, made from a composition comprising from about 35 to about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a poly(arylene sulfide), e.g. poly(phenylene sulfide).

33. A substrate as defined in claim 31, made from a composition comprising from about 35 to about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a polyester.

34. A substrate as defined in claim 31, made from a composition comprising from about 35 to about 65 weight percent of a polyarylether and from about 65 to about 35 weight percent of a poly(arylene sulfide).

35. A substrate as defined in claim 31, made from a composition comprising from about 35 to about 65 weight percent of a polyarylether and from about 65 to about 35 weight percent of a polyester.

36. A substrate as defined in one or more of the claims 31-35, which carries an electrically-conductive pathway.

37. A chip carrier made from a composition comprising from about 35 to about 65 weight percent of an amorphous polymer selected from a polyarylethersulfone, a polyarylether, a polyetherimide or a polyarylate and from about 65 to about 35 weight percent of a crystalline polymer selected from a poly(arylene sulfide), a polyester or a polyamide.

38. A chip carrier as defined as claim 37, made from a composition comprising from about 35 to about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a poly(arylene sulfide), e.g. poly(phenylene sulfide).

39. A chip carrier as defined in claim 37 made from a composition comprising from about 35 to

about 65 weight percent of a polyarylethersulfone and from about 65 to about 35 weight percent of a polyester.

40. A chip carrier as defined in claim 37 made from a composition comprising from about 35 to about 65 weight percent of a polyarylether and from about 65 to about 35 weight percent of a poly(arylene sulfide) or of a polyester.



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DOCUMENTS CONSIDERED TO BE RELEVANT		Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 4)
Category	Citation of document with indication, where appropriate, of relevant passages		
A	CHEMICAL ABSTRACTS, vol. 90, no. 10, March 1979, page 37, no. 72919n, Columbus, Ohio, US; & JP - A - 78 129 248 (UNITIKA LTD.) 11-11-1978 ---		H 01 B 3/30 C 08 L 81/06 C 08 L 79/08 C 08 L 67/02 C 08 L 71/04 C 08 L 81/02 C 08 L 77/00
A	CHEMICAL ABSTRACTS, vol. 84, no. 14, April 1979, page 33, no. 90983j, Columbus, Ohio, US; & JP - A - 75 146 648 (SUMITOMO CHEMICAL CO. LTD.) 25-11-1975 ---		
A	EP-A-0 036 959 (UNION CARBIDE) ---		
A	US-A-3 729 527 (E. NIELD) ---		TECHNICAL FIELDS SEARCHED (Int Cl 4)
A	GB-A-2 054 623 (SUMITOMO CHEMICAL CO. LTD.) ---		C 08 L
A	FR-A-2 190 873 (UNITIKA LTD.) ---		
A	DE-A-2 852 750 (UNITIKA LTD.) ---		
P,A	WO-A-8 404 753 (GENERAL ELECTRIC CO.) & EP - A - 0 122 305 --- -/-		
The present search report has been drawn up for all claims			
Place of search THE HAGUE	Date of completion of the search 05-11-1985	Examiner STIENON P.M.E.	
CATEGORY OF CITED DOCUMENTS	T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document		
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			



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DOCUMENTS CONSIDERED TO BE RELEVANT			Page 2
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
P, A	WO-A-8 403 894 (GENERAL ELECTRIC CO.) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
The present search report has been drawn up for all claims			
Place of search THE HAGUE	Date of completion of the search 05-11-1985	Examiner STIENON P.M.E.	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

**DERWENT-ACC-NO:** 1986-036858

**DERWENT-WEEK:** 199212

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**TITLE:** Polymer compsn. for insulation of electrical conductors withstands vapour phase soldering conditions without distortion, and comprises blend of amorphous and crystalline polymers

**INVENTOR:** HARRIS J E; RIMSA S B ; ROBESON L M

**PATENT-ASSIGNEE:** AMOCO CORP [STAD] , UNION CARBIDE CORP [UNIC]

**PRIORITY-DATA:** 1984US-626147 (June 29, 1984) ,  
1989US-422647 (October 17, 1989)

**PATENT-FAMILY:**

<b>PUB-NO</b>	<b>PUB-DATE</b>	<b>LANGUAGE</b>
EP 170065 A	February 5, 1986	EN
JP 61034068 A	February 18, 1986	JA
CA 1257433 A	July 11, 1989	EN
EP 170065 B	December 20, 1989	EN
DE 3574918 G	January 25, 1990	DE
JP 91071468 B	November 13, 1991	JA
US 5093435 A	March 3, 1992	EN

**DESIGNATED-STATES:** AT BE CH DE FR GB IT LI LU NL  
SE AT BE CH DE FR GB IT LI LU  
NL SE

**APPLICATION-DATA:**

<b>PUB-NO</b>	<b>APPL- DESCRIPTOR</b>	<b>APPL-NO</b>	<b>APPL-DATE</b>
EP 170065A	N/A	1985EP- 108029	June 28, 1985
EP 170065B	N/A	1985EP- 108029	June 28, 1985
JP 61034068A	N/A	1985JP- 140731	June 28, 1985
JP 91071468B	N/A	1985JP- 140731	June 28, 1985
US 5093435A	N/A	1989US- 422647	October 17, 1989

**INT-CL-CURRENT:**

<b>TYPE</b>	<b>IPC DATE</b>
CIPP	H05K1/03 20060101
CIPS	C08L101/00 20060101
CIPS	C08L67/00 20060101
CIPS	C08L67/02 20060101
CIPS	C08L71/00 20060101
CIPS	C08L71/08 20060101
CIPS	C08L71/12 20060101
CIPS	C08L77/00 20060101
CIPS	C08L79/08 20060101
CIPS	C08L81/00 20060101
CIPS	C08L81/02 20060101
CIPS	C08L81/06 20060101

CIPS	H01B3/30 20060101
CIPS	H01B3/42 20060101
CIPS	H01L23/29 20060101
CIPS	H01L23/31 20060101

**ABSTRACTED-PUB-NO:** EP 170065 A

**BASIC-ABSTRACT:**

Insulation material comprises 35-65 (pref. 40-60) wt.% of an amorphous polymer selected from a polyarylethersulphone (Ia), a polyarylether (Ib), a polyetherimide (Ic), or a polyarylate (Id); and 65-35 (pref. 60-40) wt.% of a crystalline polymer chosen from a poly(arylene sulphide) (IIa), a polyester (IIb) or a polyamide (IIc).

**USE/ADVANTAGE** – The compsns. may be used to fabricate a large variety of moulded electrical devices, e.g. printed circuit boards, chip carriers, and electrical connectors, requiring vapour phase soldering (VPS); the items maintain their dimensional integrity under such severe conditions.

<b>TITLE-TERMS:</b>	POLYMER COMPOSITION INSULATE ELECTRIC CONDUCTOR WITHSTAND VAPOUR PHASE SOLDER CONDITION DISTORT COMPRISE BLEND AMORPHOUS CRYSTAL
<b>ADDL-INDEXING- TERMS:</b>	POLY ARYL ETHER SULPHONE IMIDE POLYIMIDE POLYETHER POLYSULPHONE

**DERWENT-CLASS:** A26 A85 U11 V04 X12

**CPI-CODES:** A05-E01D2; A05-F01E2; A05-H07; A05-J01A; A05-J05; A05-J06; A07-A03; A12-E01;

**EPI-CODES:** U11-A07; U11-D01;

**UNLINKED-DERWENT-REGISTRY- NUMBERS:** ; 1520U ; 1541U ;  
5214U ; 5272U

**POLYMER-MULTIPUNCH-CODES-AND-KEY-SERIALS:**

**Key Serials:** 0004 0005 0006 0011 0013 0016  
0017 0020 0029 0031 0037 0183  
0202 0203 0205 0207 0208 0209  
0218 0231 1279 1280 1283 1285  
1291 1304 1306 1309 1319 1323  
1325 1327 1329 1363 1367 1369  
1373 1375 1377 1403 1450 1452  
1456 1458 1460 1462 1464 1487  
1717 1719 1723 1727 1804 1920  
2214 2218 2220 2334 2491 2545  
2551 2559 2585 2600 2604 2628  
2632 2635 2640 2667 2737 2740  
2743 3079 3081 3083 3085 3087  
3089 3109 3113 3115 3117 3119  
3121 3174 3175 3178 3179 3258  
3279

**Multipunch Codes:** 028 029 035 038 04- 040 045 05-  
062 063 075 08- 080 10- 141 143  
144 147 148 15- 151 153 155 156  
157 160 161 163 164 165 166 167  
168 169 170 171 173 174 192 193  
200 206 207 208 213 217 219 220  
221 222 225 229 27- 308 309 310  
331 334 38- 392 394 396 398 400  
441 46& 476 50& 506 509 51& 512  
541 542 546 55& 551 56& 560 566  
567 57& 570 573 575 577 58& 583  
586 589 59& 604 608 623 627 628  
651 654 684 688 721 722 723 724  
725

**SECONDARY-ACC-NO:**

**CPI Secondary Accession Numbers:** 1986-015478

**Non-CPI Secondary Accession Numbers:** 1986-026900